MILK, SANITARY AND OTHERWISE

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SEEING that for a length of time, extending from a number of days to a year or more, milk is the sole food of over two thousand species of animals among which are the mouse and the elephant, the porpoise and the whale, and also the bat and the flying squirrel, it is evident that it must play a very important part in the economy of nature.

Milk is sometimes called a perfect food and the milk of each species may be considered such for the young of the same species. It contains all the essentials of a food, namely, carbohydrates, fats, protein and mineral salts. Carbohydrates form a group of organic compounds, which include sugar, starch and cellulose, and are composed of carbon, of which the most common form is charcoal and of hydrogen and oxygen in the proportion in which they exist in water. Fats are also compounds of carbon, hydrogen and oxygen, but in different proportions and in a different state of combination from those found in the carbohydrates. The carbohydrates and fats burn in the body as wood or coal burns in a furnace. They are capable of supplying the heat of the body and the energy that is required for its activity but they can not build up new tissue nor repair waste. This is the function of protein, so called from the many forms in which it exists. The name is a general one for a number of more or less distinct substances which agree in having a complicated structure in which nitrogen is an essential element and in which sulphur and phosphorus frequently occur. Muscular fiber consists largely of protein, and as protein is the part of the food which supports growth it is absolutely necessary. If more protein is taken into the system than is necessary for the nutrition of the tissues, it may supply energy and heat, but, for the same amount of heating value, proteins are much more expensive than carbohydrates. Excess of protein, as well as excess of fats or carbohydrates, may be used to increase the fat of the body. Animals are fattened by heavy feeding in many cases. Protein is formed in lean meat and in the white of egg and is the essential though not the largest part of cheese.

The carbohydrate in milk is chiefly milk sugar, which is in many respects similar to cane sugar, but is not quite so sweet and is not fermentable by ordinary yeast to form alcohol.

The fat does not differ more from other fats than they do among

themselves, but it contains a small quantity of compounds which on decomposition give butyric and other acids, causing rancidity.

The proteins in milk are of two kinds, casein and albumin, and the milk of different species of animals differs more in the character of the proteins than of the other substances. Casein coagulates in the stomach by the action of rennin, albumin does not coagulate in this way. The relative quantities of these differ in different kinds of milk and the nearest to human milk in the character of the protein and indeed in all respects except the percentage of fat is that of asses. The milk of reindeer contains a large amount of fat, almost as much as the cream of ordinary cow's milk and it also contains a large amount of casein.

Though we are accustomed in this country to use only cow's milk, the milk of other animals, as is well known, is used in other lands. In Scandinavia and other northern regions reindeer's milk is a common article of diet, its fat content making it specially valuable there. Camel's milk is in favor in desert countries, mare's milk in Russia and Central Asia, while goat's milk is not only common in the hilly countries of Europe, but is sold on the streets of Paris. One of the picturesque sights of that city is a goatherd leading his flock through the streets and stopping to milk as from time to time a customer appears. In the Marais, a district not far from the Louvre, formerly an aristocratic quarter, but now a congested area of slums, a goatherd may frequently be seen sitting on the step of a door surmounted by the armorial bearings of some scion of the nobility, drawing from a goat the quarter litre of milk demanded by a ragged woman for her squalid child. Nor is goat's milk used in the poor quarters alone. Near the Bois de Boulogne, in the early morning hours one may be wakened by the sweet notes of the shepherd's pipe and may, if quick enough, catch sight of him as he jauntily leads his herd along for the benefit of this district also.

While the casein in milk is coagulated upon entrance into the stomach, that of different animals coagulates in different ways. One typical method is that of the cow, sheep, or goat, examples of ruminant animals. In these animals the casein coagulates to a solid mass, which remains for a considerable time in the stomach and is there largely digested. This prepares the stomach for the later digestion of hay and other material of a similar nature. The second typical method of coagulation is that found in the milk of the mare or ass, non-ruminant animals, whose digestion is mainly intestinal. This coagulation is gelatinous, and the material passes rapidly from the stomach to the intestines. The third form of coagulation is intermediate; flocculent masses being produced which though digested to a greater extent in the stomach than in the second case are not nearly so fully digested as in the first case. An example of this kind of flocculent coagulation is

afforded by human milk, which in this respect also more resembles that of the ass than that of the cow.

When we speak of milk without any specification we always mean cow's milk and it may be well to make a comparison between the average cow's milk and the average human milk. Of course, the great bulk is water, being a fraction over 87 per cent. in each case. In human milk the total solids are 12.6 per cent. and in cow's milk 12.8 per cent. In human milk the total protein is 2 per cent., two fifths being casein and three fifths albumin; cow's milk contains about 3.4 per cent of protein, more than five sixths of which is casein. The fats are practically the same in both kinds of milk, being 3.7 per cent. Human milk has a greater percentage of milk sugar, namely, 6.4, while cow's milk has nearly 5 per cent. The mineral matters in cow's milk are 0.7 per cent., and in human milk 0.3 per cent.

The figures given are of course an approximate average. Different breeds of cows not only give different quantities of milk, but different percentage composition as well. It may be remarked that farmers should keep an individual record of each cow so that they may know how much milk each produces, and at what cost. It is considered by good judges that one quarter of the cows kept for dairy purposes do not pay for their keep, and that nearly another quarter yield no profit, leaving only one half to bring in money. Ayrshires, Jerseys and Guernseys may be expected to give about 6,000 pounds of milk in a year, while Holstein-Friesians may be expected to give 7,500–8,000 pounds. Individual Ayrshires and Guernseys have given over 12,000 pounds, nearly 17,000 pounds have been given by Jerseys, and Holstein-Friesians have frequently been known to give 20,000–30,000 pounds. The milk of the Holstein-Friesians is usually thin, low in total solids and lacking in fat. While the average fat for Ayrshires may be taken as about 3.6 per cent. and for Guernseys and Jerseys about 5.2 per cent., that of Holsteins is about 3.4 per cent.

The fat in milk is in very fine globules and forms an emulsion. Being lighter than the rest of the milk, it is separated by its specific gravity either by rising to the top on standing or by means of a separator. It is because of its finely divided condition that cream is more easily digested than other fats. In the case of Guernsey and Jersey cows the globules are larger than in other breeds and their milk is sometimes not considered so suitable for invalids.

Milk may be deprived of part of its water, thus making it more easily transported. The term "condensed milk" is applied to milk that has been partially evaporated and to which sugar has been added. "Plain condensed milk" means milk concentrated without addition of sugar and it is commonly sold in bulk. "Evaporated milk" is normal milk reduced to about half its original volume. It is similar in keeping

power to pasteurized milk and is chiefly used by confectioners and ice-cream manufacturers. Condensed milk if obtained from whole milk has about one third the original volume, if from skim milk one fourth. The condensation is usually effected in vacuum pans, by which means the water evaporates at a comparatively low temperature, thus changing the character of the contents but slightly. In 1912 the condensed milk factories in the United States had a capacity of about 15,000,000 pounds a day, the product probably of a million cows, though under proper conditions a million cows should yield a greater amount of milk.

A further step in the removal of water produces desiccated milk. The process, however, is quite different, for, in order to prevent change in the character of the solids, the evaporation must be very rapid. The milk is dried at a temperature of about 220–230° F. in about thirty seconds. When the milk powder is mixed with water in the proper proportions milk similar to the original is obtained. Approximately 90 per cent. of the desiccated milk manufactured is made from skim milk; the fat of whole milk is liable to become rancid on long keeping. Desiccated milk is completely free from bacteria; germs can not develop in it. The process is in use in many of the best dairies in Europe, also in Australia and the Argentine Republic.

A number of years ago an experiment was made in New York with 850 babies ranging from five days to a year old. Sugar of milk was added to the dried milk which was sometimes whole milk and sometimes different mixtures of milk and cream. This was fed during the four hottest months of the year. The mothers were instructed how to mix the powder with water and were told not to keep the milk any length of time after it was made up but to throw away whatever was left by the infant. Not a single child died. It was found that this milk did not clot in the stomach like ordinary milk, but in granular clots like human milk.

A very important characteristic of milk is that it is peculiarly adapted to the growth of lower organisms among which bacteria of various kinds are prominent. It is a food for them as it is a food for higher organisms. The souring of milk is brought about by bacteria which change milk sugar into lactic acid. These bacteria do not propagate by spores, and as it is spores that can stand the greatest variations of temperature the lactic acid bacteria are destroyed at a temperature not very high. Lactic acid bacteria are widespread, and it is almost impossible to get milk that does not contain them. As the milk sours the casein combines with the acid, forming a curd. When the milk begins to taste sour the growth of nearly all non-acid-forming bacteria is checked and in distinctly sour milk the bacteria are usually confined to two or three closely related varieties. Lactic acid bacteria are con-

sidered very beneficial in butter and cheese making, though usually thought to be objectionable in milk.

Besides the sour curdling of milk there is a sweet curdling similar to what takes place in the stomach when milk is drunk. The rennet of calves is used for the purpose. It contains what is technically called an enzyme. The curd is changed afterwards into a soluble material by another enzyme, pepsin. These are bacteria that produce similar enzymes and so a curd may be digested, as it were, by these bacteria. Sometimes the weather may be so hot as to be more suitable for these bacteria than for those producing lactic acid, and very little curd may be formed.

While speaking of casein it may be well to mention that when casein is subjected to great pressure it is converted into a ductile substance called lactite, which may be used instead of celluloid as an imitation ivory, for napkin rings, combs, handles of knives and walking sticks and for the veneering of furniture.

The typical lactic acid bacteria have, so far as known, no poisonous products and sour milk is probably valuable in many diseases, especially those which arise from putrefying bacteria in the intestines. Other bacteria which produce a ropy condition of the milk are also not considered harmful, but to most people ropy milk is disagreeable. The ropiness is due not to the curdling of casein, but to the bacteria themselves, which are held together by a slimy substance secreted by them. Koumiss, originally made from mare's milk, combines an alcoholic fermentation with that of lactic acid. The alcoholic fermentation is brought about in milk sugar not by the ordinary yeast used in making bread, but by a special variety.

Of course, the most important bacteria from the point of view of the consumer are the disease-producing ones. Epidemics of diphtheria and scarlet fever have been traced to milk, also typhoid fever and other diseases. It has been matter of debate whether tuberculosis is transmitted from animals to man, but the balance of expert opinion favors the view that it is. Tuberculosis is very prevalent among cows. In a test made at Washington on 1,538 cows belonging to 104 herds supplying milk to that city it was found that 16.9 per cent. had tuberculosis and this was considered to be below the average, which was estimated to be about 25 per cent. It is not uncommon to find 70–80 per cent. of a herd diseased.

Disease-producing bacteria are seldom isolated from or counted in milk. The total number of bacteria is counted and the count is usually merely an indication of how carefully the milk has been collected or the temperature at which it has been kept. If cleanliness has not been observed at all stages or if the temperature has not been kept down to about 50° F. or lower the bacteria are certain to number many thou-

sands and perhaps millions in a cubic centimeter. Hence for good milk it is important that the cows should be healthy and that the stables should be kept clean. The floors should be made of cement or some non-porous material so that animal waste may be easily removed; the walls should be smooth and without ledges where dust may gather and should be easily washed. Special pains should be taken with the ventilation, the air space for each cow should be at least 600 cubic feet, and there should be large window space, affording abundant light, since light is one of the best germicides. Moreover the cows themselves should be kept clean. They should be carefully groomed and even washed. The grooming should take place some time before the milking so that dust and hairs may not be floating in the air. It is an advantage if a building separate from the stable is used for the milking and that only.

The milker's clothes should be scrupulously clean; a white suit similar to that used by surgeons during an operation is to be recommended. The milk should be caught in a narrow-mouthed pail so as to admit as little dust as possible. The milker should not pass from one cow to another without washing his hands and the milk should be immediately taken to the milk house, where it should be cooled at once. Naturally the milk house must be clean; and all the vessels used should be sterilized by being kept for two minutes in boiling water or, still better, live steam. It is evident that the milk house must be abundantly supplied with hot and cold water.

No matter how carefully and cleanly the milk is produced, if during transportation and delivery it is open to contamination, the consumer is little benefited by the care exercised during the early operations. As soon, then, as the milk is cooled it should be placed in perfectly clean bottles and covered. The paper covers that are often supplied are better than nothing if they are reasonably clean but they are far from ideal. They are difficult to make and to keep sterile. In the "Uviol" method of bottling, tops are made of tin foil coated on the lower side with a germ-free stiffening material and kept in a germ-free package till required for use; and they are put on the bottle by machinery without being touched by the hands during any part of the operation.

The consumer must also observe care in the treatment of milk after it has been delivered. If there is disease in the house, special care is necessary; but many bacteria besides those of contagious diseases are detrimental to milk, some of them causing digestive disorders which in the case of babies may prove fatal. The vessels used for milk should be perfectly clean and the milk should not be exposed to flies and, as little as possible, to the air; and it should be kept cold. Flies are known to have caused typhoid fever; 100,000 *fecal* bacteria have been found on a single fly; while in a particular experiment in which 414

flies were examined there was an average of a million and a quarter bacteria of all kinds on each fly; and flies are common carriers of those bacteria that derange the intestinal system. Vessels used for milk should not be washed with the ordinary dish water but with fresh water. They should not be dried with a towel but should be rinsed with scalding water or still better boiled in water and set away unwiped but turned so that the water may drain out.

The growth of bacteria is inhibited either by low temperature or by high. While at 50° F. the bacteria increase about fourfold in twenty-four hours, and sixfold in forty-eight hours; at about 70° F., they multiply more than 6,000 times in twenty-four hours and nearly 400,000 times in forty-eight hours. These numbers are only typical of the order of growth which varies with different kinds of bacteria, but they illustrate the fact that it is very advisable to keep the temperature down to 50° F. or even better to 40° F.

On the other hand, a sufficiently high temperature destroys microbic growth. This temperature is above the boiling point of water and must be applied under pressure. Such a process is called sterilization. But this high temperature changes the character of the milk, and the growth of bacteria can be much lessened at a lower temperature by the operation called pasteurization. Two processes of pasteurization have been adopted; in the "flash" method the milk is exposed to a temperature of 160° F. for thirty seconds, in the "holder" method it is maintained at a temperature between 140° and 150° F. for thirty minutes. This last method may be carried out in the containing bottles if desired. At 145° F. all of the *disease* germs are destroyed and the majority of the others as well. At this temperature with long exposure a greater number of the putrefying germs in proportion to the souring germs are destroyed than by short exposure at a higher temperature, and as the putrefying germs are the most detrimental, the longer process is the better. Pasteurization does not prevent future growth of bacteria, which propagate with rapidity at blood heat. So after pasteurization the milk should be cooled immediately to a low temperature and kept at a low temperature till required for use. Sometimes thermos bottles are employed for keeping warm, through the night or during a journey, milk intended for babies. If the temperature is sufficiently high, say 145° F., most bacteria do not develop, but on the other hand some whose action is unknown grow in large quantities and if the temperature should fall to 100°–110° F. many bacteria develop so rapidly that in three or four hours the milk is quite unfit for infant's food. Thermos bottles may be used for keeping milk on a journey; but only for keeping it cold. If placed in a thermos bottle at about freezing temperature it will probably keep cool for a long time.

Eighty-eight per cent. of the milk supplied to New York is pasteurized, and 80 per cent. of that supplied to Boston.

In view of the importance of having milk that can be depended upon, medical milk commissions have been established, of which there are less than a hundred in the United States; in Canada there are only two or three. These commissions provide inspectors who frequently examine the herds to see that there are no diseased cows and that the employees are healthy, that the stables and other premises are clean, that the milk is properly treated and cared for during transportation and that it is delivered as soon as possible, thirty hours being the outside limit.

The milk itself is analyzed, the solid contents must be within certain limits and the number of bacteria must be low. Score cards are kept in which certain values are assigned to each feature and in order to be certified the milk must total a certain percentage. The lowest score of a certified dairy of which in 1913 there was any record in the U. S. Bureau of Animal Industry at Washington was 73.6 per cent. and the average of thirty-seven certified milk farms was 90 per cent. At the same time 953 dairies supplying milk in the ordinary way were scored and the average was 41.6 per cent.

About one half of one per cent. of the milk supplied in the United States is certified. The cost is approximately double that of ordinary milk, a matter of consideration to the general consumer but of practically no importance where the health or indeed the life of an infant may be concerned. It should be noted that certified milk is not pasteurized, but is cooled immediately after milking.

It is naturally where milk is to be used by infants that the greatest care is necessary. Every effort should be taken to make the replacement, where necessary, of mother's milk by cow's milk as little injurious as possible.

At Berlin, in 1885, when doubtless hygienic considerations were less attended to than now, the mortality among infants under a year old was that given by the following table:

Infants Fed by	Death Rate per 1,000
Mother's milk	7.6
Nurse's milk	7.4
Animal and human milk	23.6
Animal milk alone	45.6
Animal milk and milk substitute	74.8

So in children's hospitals, children are fed with milk made as nearly like human milk as may be, and every pains is taken that it shall be thoroughly hygienic.

Several years ago Dr. Ralph Vincent, senior physician to the In-

fant's Hospital, Westminster, wrote an article in *Science Progress* upon the milk supplied in that hospital. He pointed out that while well-nurtured children easily get over infectious diseases, badly-nurtured ones recover with difficulty and that complications usually arise. He discussed the contaminated character of the milk supply, especially among the poor of large cities, explained that contaminated milk when boiled is still contaminated and asserted that among the poor the boiling of milk plays an important part in the production of the most fatal disease of infancy, zymotic enteritis, which is largely caused by the putrefactive decomposition of boiled milk.

The milk used at the hospital is very similar to that demanded of certified milk by the medical milk commissions, but in some respects special precautions are taken. There is a rigorous supervision of the diet of the cows. No oil cake nor brewers' grain nor distillery grain is allowed, but grass, hay, pea and bean meal, and mangolds are the chief food. Jersey and Guernsey cows are not admitted to the herd, since the large fat globules are considered too indigestible for invalid children. The milk is delivered within four hours after milking.

Cow's milk has less milk sugar and more casein than human milk. When casein is separated from milk by means of rennet the whey contains the albumin as well as the milk sugar or lactose. The fat content in human milk and cow's milk is the same, so dilution of the milk by addition of whey would make the fat content too low. It is found best to separate the fat from the milk and to mix skim milk and cream in the proper proportions afterwards. Human milk is alkaline and lime-water is used to produce the required condition.

Mother's milk varies with the age of the child as well as with the individual; and in the hospital the nurses make up the food for each infant according to prescription of the six ingredients, of which some are artificial solutions, provided for the purpose. The following is a typical prescription.

	C.c.
Cream (32 per cent. fat)	75
Lactose solution (2 per cent.)	121
Whey	858
Fat-free milk	59
Lime water	60
Sterile water	27
	1,200

The milk mixture is then carefully put into separate bottles, one for each feeding. Many thousands of such combinations are used at the hospital. The milk is kept at 40° F. and the constituents are kept at the same temperature or lower. Just before the milk as modified is given to the infant it is warmed to 100° F., but none of this that is left is kept over for use at a later time.

It might be thought that milk produced with so much care would necessarily be expensive, but Dr. Vincent states that due to economy, among other things by having no cows that do not give a good return for the cost of keep, the expense is not greater than the average for ordinary milk and in fact that the hospital pays only 75 per cent. of the average price of ordinary milk in the metropolis of London. It would seem that in American cities it ought to be possible to procure milk of the grade of certified milk at a less advance beyond the ordinary price than is usually charged.

As old age comes on it appears that milk again becomes a specially valuable diet. In this case buttermilk and other fermented milks are said to be particularly suitable. This subject is, however, not one to be taken up at the end of a paper.